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Short Communication

Magnetic stimulation of peripheral nerves in dogs: A pilot study

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Abstract

A model for magnetic stimulation of the radial and sciatic nerves in dogs was evaluated. Onset-latencies and peak-to-peak amplitudes of magnetic and electrical stimulation of the sciatic nerve were compared, and the effect of the direction of the current in the magnetic coil on onset-latencies and peak-to-peak amplitude of the magnetic motor evoked potential was studied in both nerves. The results demonstrate that magnetic stimulation is a feasible method for stimulating the radial and sciatic nerves in dogs. No significant differences were observed in onset-latencies and peak-to-peak amplitudes during magnetic and electrical stimulation, indicating conformity between the techniques. Orthodromic or antidromic magnetic nerve stimulation resulted in no significant differences. This pilot study demonstrates the potential of magnetic stimulation of nerves in dogs.

Keywords: Magnetic stimulation; Dogs; Peripheral nerves

In veterinary medicine, electrodiagnostic evaluation of peripheral nerve disorders is mostly achieved by electrical stimulation of peripheral nerves (Cuddon, 2002), but little is known about magnetic nerve stimulation in animals (Heckmann et al., 1989). With electrical stimulation, current is passed into the body via needle electrodes, whereas in magnetic stimulation a brief magnetic pulse induces a current in conductive tissues (Barker, 1991). Magnetic stimulation provides a non-invasive and almost painless alternative to electrical nerve stimulation.

We have evaluated a model for magnetic stimulation of the radial and sciatic nerves in dogs and compared onset-latencies and peak-to-peak amplitudes during magnetic and electrical stimulation of the sciatic nerve. The effect of the direction of the current flow in the magnetic coil on onset-latency and peak-to-peak amplitude of the magnetic motor evoked potential was studied. Procedures were performed under general anaesthesia on six mongrel dogs of similar height at the withers the local ethical committee of the faculty of Veterinary Medicine of the University of Ghent approved the work.

A commercially available magnetic stimulator (Magstim Super Rapid, Magstim Company) was connected to a circular coil (45 mm). For magnetic stimulation of the radial nerve, the magnetic coil was placed in the axillary region, medial to the radial nerve, and the cranial part of the circle on the coil was held tangentially to the radial nerve (Fig. 1). For magnetic stimulation of the sciatic nerve, the magnetic coil was placed lateral to the hind limb and the caudal part of the circle on the coil was held tangentially to the sciatic nerve between the greater trochanter and the ischial tuberosity (Fig. 2).

For both nerves, the flat surface of the coil was placed parallel to the surface of the skin of the limb. Both nerves were stimulated with the current in the coil flowing in both clockwise (orthodromic nerve stimulation) and counter

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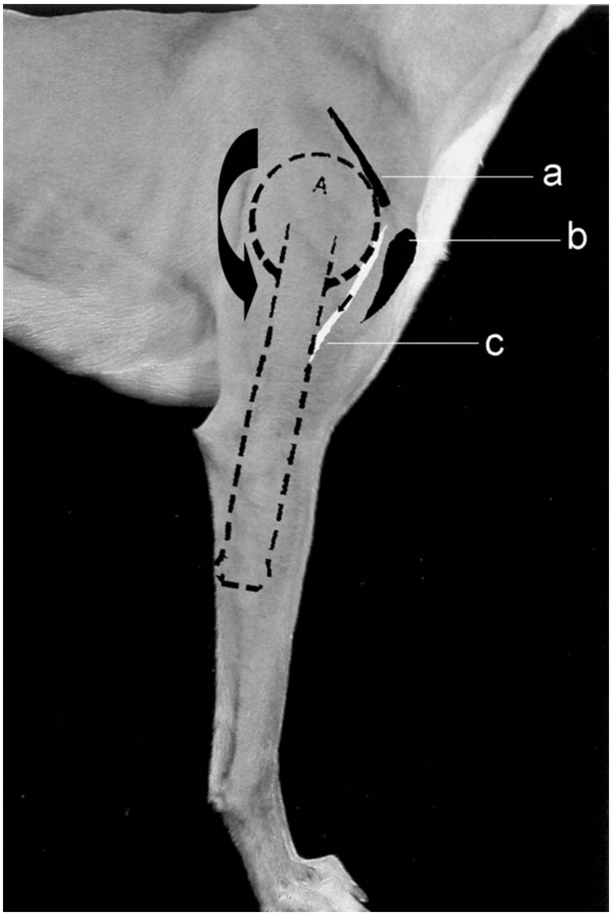

Fig. 1. Magnetic stimulation of the radial nerve: Position of the magnetic coil. Schematic view of orthodromic nerve stimulation (current in the coil is clockwise; point of view is always with the coil between the examiner and the nerve). For antidromic nerve stimulation, the magnetic coil is reversed. (a) Spina scapulae. (b) Humerus (greater tubercle). (c) Radial nerve. Small arrow: Direction of induced current in the radial nerve. Large arrow: Direction of the current in the magnetic coil.

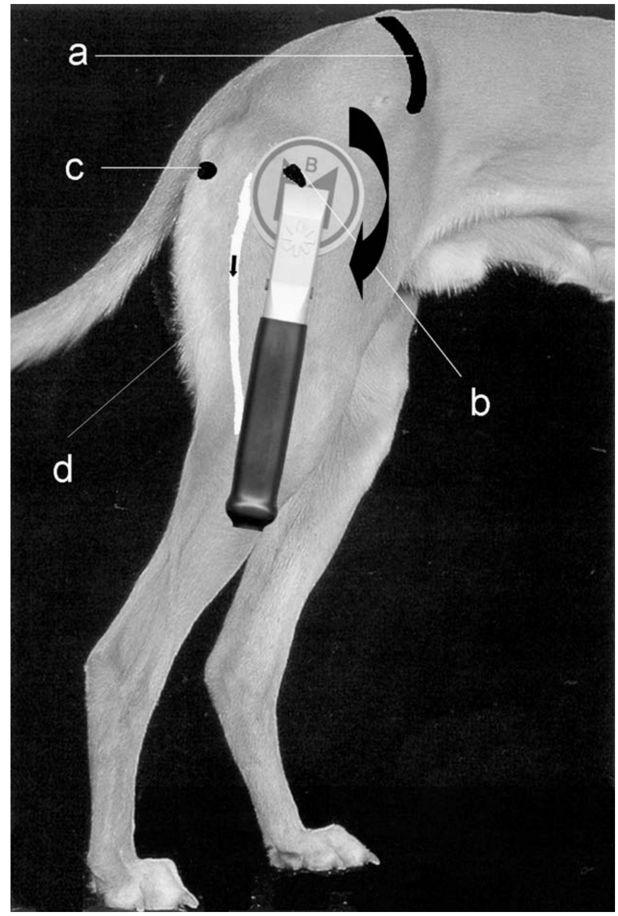

Fig. 2. Magnetic stimulation of the sciatic nerve: Position of the magnetic coil. Schematic view of orthodromic nerve stimulation (current in the coil is clockwise; point of view is always with the coil between the examiner and the nerve). For antidromic nerve stimulation, the magnetic coil is reversed. (a) Ilium (crest). (b) Femur (greater trochanter). (c) Ischium (tuber ischiadicum). (d) Sciatic nerve. Small arrow: Direction of induced current in the sciatic nerve. Large arrow: Direction of the current in the magnetic coil.

clockwise (antidromic nerve stimulation) directions by reversing the coil. Electrical stimulation of the sciatic nerve was done using the stimulator of an electromyograph (Sapphire, Meda). The cathodal and anodal stimulating electrodes (monopolar needle electrode, Meda) were placed between the greater trochanter and the ischial tuberosity. Stimulus intensity was increased until supramaximal responses were obtained.

Recording electrodes (monopolar needle electrodes, Meda) were placed in the muscle belly, just in front of the lateral humeral epicondyle for the extensor carpi radialis muscle (ECRM) and slightly lateral to the distal end of the tibial crest for the cranial tibial muscle (CTM). Reference electrodes (subdermal needle electrodes, Meda) were positioned at the carpal and the tarsal joints for the ECRM and CTM, respectively. The ground electrode (subdermal needle electrodes, Meda) was placed over the olecranon of the forelimb or over the patella of the hind limb. All recordings were made using the same electromyograph (Sapphire, Meda). No signal averaging was performed.

Measurements of onset-latency and peak-to-peak amplitude were made using the cursors on the oscilloscope. Onset-latency was measured between stimulus artefact and deflection from the baseline in either a positive or a negative direction. Peak-to-peak amplitude was the amplitude measured from the peak of the negative-going wave and from the nadir of the positive-going wave (Fig. 3).

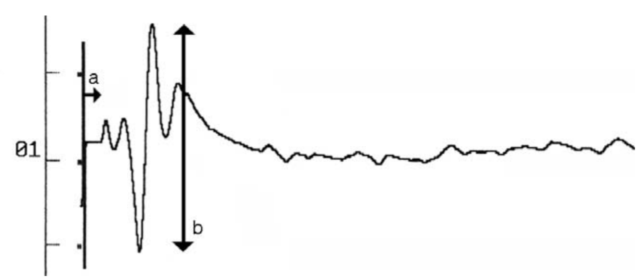

Fig. 3. Magnetic motor evoked potential: Onset-latency and peak-to-peak amplitude measurement. (a) Onset-latency. (b) Peak-to-peak amplitude.

Table 1
Median onset-latencies and median peak-to-peak amplitudes from the cranial tibial muscle (CTM) recordings after magnetic and electrical stimulation of the sciatic nerve

Stimulation	Onset-latency (range), $n = 6$	Peak-to-peak amplitude (range), $n = 6$
Magnetic	3.6 (2.8–4.5) ms	25.16 (0.82–32.41) mV
Electrical	3.2 (3.2–4.1) ms	27.885 (18.36–31.81) mV
P-value	0.6276	0.3125

Table 2
Median onset-latencies and median peak-to-peak amplitude from extensor carpi radialis muscle (ECRM) and cranial tibial muscle (CTM) recordings after radial and sciatic magnetic nerve stimulation, respectively

	Onset-latency (range), $n = 6$	Peak-to-peak amplitude (range), $n = 6$
Radial nerve		
Orthodromic nerve stimulation	2.6 (1.6–3.4) ms	23.545 (17.58–33.59) mV
Antidromic nerve stimulation	2.65 (1.6–3.6) ms	23.05 (14.65–36.51) mV
P-value	0.625	0.5625
Sciatic nerve		
Orthodromic nerve stimulation	3.35 (2.8–3.7) ms	22.085 (0.47–35.54) mV
Antidromic nerve stimulation	3.65 (3.2–4.1) ms	12.75 (2.15–25.7) mV
P-value	0.125	0.0625

One observation per technique and per nerve was used for statistical analysis. The Wilcoxon matched-pairs signed ranks test was used for identification of statistical significances between peak-to-peak amplitudes after magnetic and electrical stimulation of the sciatic nerve and between onset-latencies and peak-to-peak amplitudes after orthodromic and antidromic magnetic stimulation of the radial and sciatic nerves. The Mann–Whitney test was used for comparing the variable onset-latency of magnetic and electrical stimulation (GraphPad Instat, GraphPad Software). Differences with $P<0.05$ were considered to be statistically significant.

Biphasic to polyphasic potentials were easily recorded after magnetic stimulation of the radial and sciatic nerves, respectively. Median onset-latencies and median peak-to-peak amplitudes after stimulation of the sciatic nerve, first using magnetic stimulation (orthodromic nerve stimulation) and then using electrical stimulation are given in Table 1. No significant differences in onset-latencies and peak-to-peak amplitudes were observed for both techniques. Median onset-latencies and median peak-to-peak amplitudes for all recordings after magnetic stimulation of both nerves are given in Table 2. No significant differences were found in onset-latencies and peak-to-peak amplitudes when the current in the coil was flowing in either a counter-clockwise direction (antidromic nerve stimulation) or in a clockwise direction (orthodromic nerve stimulation) after magnetic stimulation of both nerves.

The results of this study demonstrate that magnetic stimulation provides a feasible, non-invasive method to stimulate the radial and sciatic nerves in dogs. Magnetic nerve stimulation has major advantages over conventional electrical stimulation. These include the ability to stimulate peripheral nerves without discomfort, which make it possible to perform the technique under sedation. Needle electrodes are not necessary to stimulate the nerve and, as such, deep or relatively inaccessible nerves (e.g., radial, sciatic and facial nerves) can be stimulated easily. Similarly, no mechanical contact is needed with the body, which makes it possible to investigate traumatised regions or to stimulate across sterile barriers (Barker, 1991).

The disadvantages of the technique are (1) problems in obtaining a consistent supramaximal response as compared to the response obtained after electrical stimulation and (2) defining the exact site of localisation (Evans et al., 1988). In the present study, no significant differences in onset-latencies and peak-to-peak amplitudes between magnetic and electrical stimulation of the sciatic nerve were observed. However, the limited number of dogs and nerves examined in the present study should be taken into account before the magnetic coil can be recommended for general use.

The current flow in the stimulator head is opposite to the induced current in the tissue (Evans, 1991). Reversing the magnetic coil and thus reversing the direction of the induced current in the tissue had no significant influence on the evoked potential. However, consistent use of one side of the coil is recommended because the configuration and the latency of the response can change as the coil is reversed (Chokroverty, 1989).

In conclusion, this study demonstrates the potential for magnetic stimulation of nerves in dogs. Further studies on magnetic stimulation of different nerves and on the clinical application of magnetic stimulation in peripheral nerve disorders should be evaluated.

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